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MODEL 010
DIGITAL VOLTMETER ACCESSORY MODULE

DANA™

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Instruction Manual
980209

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January, 1967

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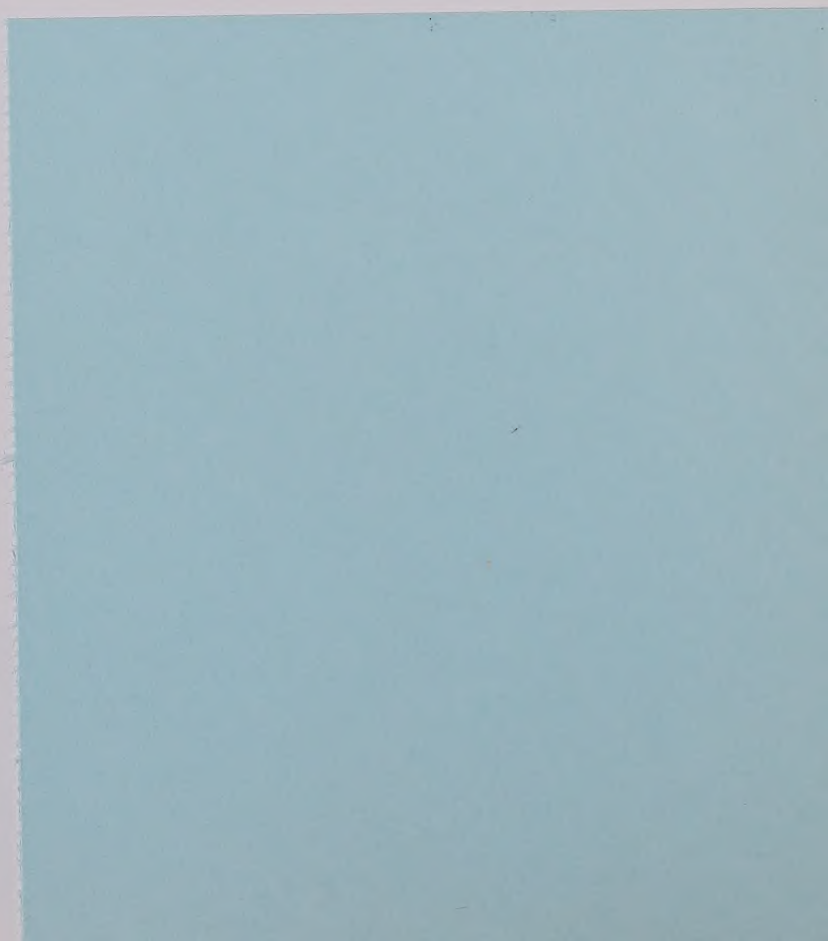

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Section 1

General Description

1.1 INTRODUCTION

This manual describes the Model 010 Accessory Module used with Dana Models 5400 and 5403 Digital Voltmeters. With the 010 Accessory, the meter becomes a dc instrument capable of measuring voltages from 1 millivolt to 1000 volts and ±DC/+DC ratios. Output readings are displayed on a four-digit visual read-out with an electrical output available for driving a printer or other recording device. Accuracy is preserved at the range cross-over points by a fifth "over-range" digit that extends each range by 10% (9999 to 10999).

The Model 010 Accessory Module (in the right-hand drawer of the instrument) is a signal conditioning unit for the Digitizing and Display module in the left-hand drawer. It's function is to condition the input and scale it for measurement by the Digitizing and Display module. The Digitizing and Display Module is covered in a separate manual.

Figure 1.1. Module 010 Installed in Model 5400 DVM

The type of measurement is selected by a Function switch on the front panel of Module 010:

DC FAST	for high speed, non-filtered measurements of DC signals from 1 millivolt to 1,000 volts.
DC	for stable, medium-speed measurements of DC signals from 1 millivolt to 1,000 volts.
RATIO	for bipolar (+/+ or -/+) ratio measurements between a ±DC input signal and a +DC reference voltage.
REMOTE	allows the type of measurement to be selected by a remote contact closure in conjunction with a Digital Output and Programming Accessory.

A separate front panel switch permits the measurement range to be selected manually, automatically, or by remote contact closures.

Two additional standard features of the 010 Module are the Automatic Ranging function and the Analog output. With automatic ranging (Auto Range), circuits within the instrument determine the optimum range for the function being measured and switch to that range automatically. An analog output voltage, proportional to the signal being measured, is available at terminals on the front panel of the instrument. This voltage, at ten volts full scale, allows analog recordings to be made in parallel with digital measurements. Many other applications for the analog output are possible — including its use as a precision voltage source.

All circuitry in the instrument is mounted on plug-in boards, inserted from the top. The Digital Output and Programming Accessory, which is plugged into the space provided on the rear panel, can be added at any time.

The following table identifies component locations and Figure 1.2 is a block diagram that shows the function of the boards in the operation of the instrument.

REAR

Electrical Output/Programming Accessory	Power Supply
Digitizing and Display Module	J18 - Auto Polarity J17 - Auto Range J16 - Isolator J15 - Control & Attenuator

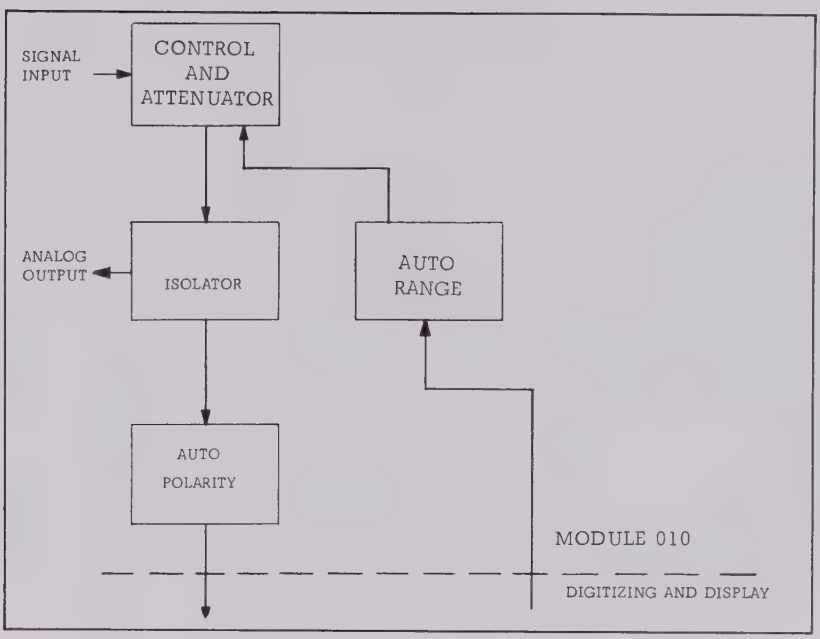


Figure 1.2. Block Diagram

1.2 MEASUREMENT TECHNIQUE

The Digitizing and Display Module of the digital voltmeter uses the null balance technique to measure the Amplitude of unknown voltages.

The signal conditioning and ranging circuits contained in Module 010 convert the input signal to a 10-volt full-scale analog voltage. For example, if the digital voltmeter controls are set to measure DC volts on the 100-volt range, a 50-volt input signal will result in an internal analog voltage of 5 volts DC. The analog voltage from Module 010 is "digitized" in the Digitizing and Display module by comparing it with a series of trial-and-error voltages, each of which is a known digital fraction of a reference voltage. The precision resistors in the reference-current divider or digital-to-analog converter (DAC) are capable of dividing the reference into 10,000 equally-spaced current increments and to arrive at the closest increment in a maximum of 36 trials. The total digitizing time is less than 2 milliseconds.

When a null balance has been achieved, the digital setting of the DAC is displayed on the DVM visual readout. The number shown is, in effect, the ratio between the input signal and the reference voltage in parts per 10,000.

When absolute measurements are being made, a highly stable, Zener controlled, 10-volt internal reference is used. Since the full scale analog voltage from Module 010 circuitry is also 10 volts, (converted to a precision current) the

21.2
87.7

displayed value can be read directly in DC volts, with a proper placing of the decimal point to compensate for any ranging that has been performed.

In the above example, the 50-volt DC input signal would produce a 5-volt internal analog voltage, which would be balanced by the 10-volt internal reference when the DAC arrives at a value of 5,000 (parts per 10,000). The digital display would carry the numerals 5-0-0-0, and range information from Module 010 circuitry would place the decimal point to read 50.00.

In the ratio measuring mode, the internal 10-volt reference is replaced by a positive external DC voltage, which may vary from +1 to +11 volts. The displayed value is the ratio between a DC input signal and the reference voltage at that instant. The ratio between +DC voltages and the reference are shown as plus (+) ratios; the ratio between -DC voltage and the reference as minus (-) ratios (the external reference must always be positive). This bipolar ratio capability is of particular value in applications such as bridge balancing, where the inputs are likely to pass through zero. Since the signal and reference voltages are being detected simultaneously, the accuracy of the ratio measurement is independent of the stability of the voltage source.

1.3 SPECIFICATIONS

Specifications are listed in Table 2.1.

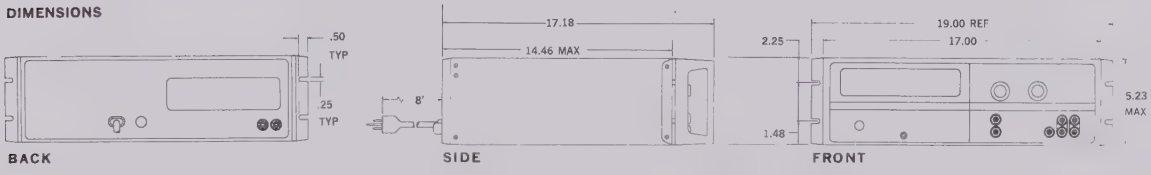
Table 1.2. Specifications

DC VOLTAGE MEASUREMENTS (MODULES 005, 010, 020, 030)	ABSOLUTE (0 to ±1000 v)	RATIOS (+1 to +11 v ref std, +10 to +110 available)
Full scale ranges, ranging and polarity automatic	±10.999, ±109.99, ±1099.9 v (max input 1000 v)	±1.0999:1, ±10.999:1, ±109.99:1
Accuracy	±0.01% of reading and ±0.01% of f.s.	±0.01% of reading and ±0.01 (10v/E ref)% of f.s.
Temperature coefficient	±0.001% of reading per °C	±0.001% of reading per °C
Response time: Digitizing with polarity change	2 milliseconds	2 milliseconds
Range change	250 milliseconds per range	250 milliseconds per range
Full scale step function settling time (to 0.01%)	250 milliseconds with up to 100k-ohm source	250 milliseconds with up to 100k-ohm source
Common mode rejection: DC	error <0.01% f.s. per 100 v common mode, with up to 100 ohms in either lead	error <0.01% f.s. per 100 v common mode, with up to 100 ohms in either lead
AC, 61 Hz and below	error <0.01% f.s. per 10 v common mode, with up to 100 ohms in either lead	error <0.01% f.s. per 10 v common mode, with up to 100 ohms in either lead
Normal mode noise rejection	40 db min, 59 Hz and up; increasing 18 db/octave; 80 db min, 300 Hz and above; three-pole Gaussian	same as absolute (input only)
Input resistance—at or off null: 10 range	1000 megohms	signal, 1000 megohms; ref, 20 megohms
other ranges	10 megohms	signal, 10 megohms; ref, 20 megohms

DC VOLTAGE MEASUREMENTS, FAST (MODULES 010, 020, 030)	
Full scale ranges, ranging and polarity automatic	±10.999, ±109.99, ±1099.9 volts (max input 1000 volts)
Accuracy	±0.01% of reading and ±0.01% of f.s.
Temperature coefficient	±0.001% of reading per °C
Response time: Digitizing with polarity change	2 milliseconds
Range change	250 milliseconds per range
Full scale step function settling time (to 0.01%)	10 milliseconds with up to 100k-ohm source
Common mode rejection: DC	error <0.01% f.s. per 100 v common mode, with up to 100 ohms in either lead
AC, 61 Hz and below	error <0.01% f.s. per 3 v common mode, with up to 100 ohms in either lead
Input resistance—at or off null: 10 v range	1000 megohms
other ranges	10 megohms

GENERAL SPECIFICATIONS AND ORDERING INFORMATION (MODULES 005, 010, 015, 020, 030)	
Maximum common mode voltage	250 volts
Maximum power requirement	40 watts, 105 to 125 v (export 210 to 250v), 50 to 400 Hz
Warm up	1/2 hour to full accuracy
Operating temperature range	0° to +50°C
Signal input binding post connectors	front input: all instruments. Parallel rear input: (extra cost option) $40 (add -1 to model and module numbers, e.g., 5400-1/030-1).
Reference input binding post connectors	rear only
Convenience hardware	Handles, part no. H450820, $15 per set. Rack Mounting Flanges, part no. F450820, $15 per set. Integral Handles-and-Flanges, part no. FH450820, $15 per set. Card Extender, part no. 410184, $15.
Weight	25 pounds (approx) net, 30 pounds (approx) shipping
Guarantee	12 months, faulty workmanship or component failure

DIMENSIONS



BACK SIDE FRONT

Section 2

Installation

2.1 UNPACKING AND INSPECTION

The Digital Voltmeter is crated in a plastic foam container consisting of two half-forms joined together and securely taped. The forms are contoured so as to hold the digital voltmeter firmly in place with the container absorbing any reasonable external shock. Before uncrating, examine the container for any sign of external damage.

Carefully cut the tape holding the two half-forms together and remove the digital voltmeter. Inspect the digital voltmeter for signs of damage. If damage is found, notify the carrier immediately.

Remove the two modules from the DVM enclosure by turning the knurled knobs counterclockwise and pulling on the aluminum channel across the front panel of each module. Be sure that all circuit boards are firmly seated in their connectors. Normally, there is no need to remove each board; however, a visual check for obvious damage should be made.

Reseat the modules by pressing them firmly into the connectors at the rear of each drawer assembly. Lock in place by turning the knurled knobs fully clockwise.

The instrument, as shipped, is designed for bench-top operation. A standup bracket is provided under the case to aid in reading the visual display. To adapt the unit for rack mounting, flanges are attached by removing the wto screws holding the side panels to the front bezel casting and replacing them with the longer screws provided with the rack-mounting flanges. The flanges are supplied in pairs, with Part No. F-450820 applying to a pair of flanges alone. For integral flanges and carrying handles, specify Part No. FH-450820. For carrying handles only, specify Part No. H-450820.

2.2 POWER CONNECTIONS

A standard eight-foot, three-wire, power cable is supplied with the instrument. This cord connects to a three-pin power connector at the rear of the unit.

2.3 INPUT/OUTPUT CONNECTIONS

2.3.1 Inputs/Analog Output

Signal input and analog output binding posts are located on the front of the accessory module. Binding posts for the reference input, used in ratio measurements, are located on the rear of the unit. Connections to these terminals are made with standard "banana" plugs. Models equipped with a rear input connector (designated as Model 010-1) use a six-pin cable connector wired in parallel with the front-panel binding posts. The mating connector is supplied with the instrument. See Paragraph 2.4 for instructions on the use of the analog output. Pin assignments of the rear input connector are listed below. See Table 2.1 for identification of connectors.

Pin A	Signal Input +
Pin B	Signal Input -
Pins C through F	Not Used in 5400/010

2.3.2 Remote Programming/Electrical Output

The Remote Programming/Electrical Output Accessory fits into the rear panel of the digital voltmeter. It carries two 50-pin connectors. The connector on the right-hand side (as viewed from the rear) is the digital output connector, J202. The connector on the left is the remote programming connector, J204. Printers and other digital recording devices may be driven by the signals present on the pins of the electrical output connector. Functions and ranges can be selected and remote commands generated through pins of the remote programming connector.

Pin assignments of the two connectors, along with wiring and programming instructions, are included in the "Electrical Output and Programming Options" manual.

Table 2.1. Connector Identification

Connector	Dana P/N	Mfr.	P/N
Digital Output J202	600015	Amphenol	57-40500
Mating Connector	600047	Amphenol	57-30500
Rear Input J203	600259	Amphenol	97-3102A-14S-6S-639
Mating Connector	600260	Amphenol	97-3106A-14S-6P-639
Hood	601639	Amphenol	97-3057-6A-639
Remote Programming J204	600015	Amphenol	57-40500
Mating Connector	600047	Amphenol	57-30500

2.4 ANALOG OUTPUT

The analog output at the front panel terminals is ±10 volts full scale for ±DC signals, both volts and millivolts. This voltage is increased by approximately 10% in the overrange condition. The analog output should drive a 100,000 ohm load (minimum) for maximum accuracy.

In connecting the analog output to a strip-chart recorder or other analog device, it should be recognized that the black terminal of the analog-output pair is internally connected to the black signal-input connector. Ideally, therefore, floating or isolated recorders should be used to avoid ground loop problems.

2.5 CHECKOUT PROCEDURE

Every instrument is completely checked out and calibrated before leaving the factory. The following procedure is performed to verify that no damage has occurred during shipment and that the instrument is operative. Slight deviations in readings during the following tests may be corrected by making simple adjustments. For instructions, refer to "Field Calibration." Any major discrepancies should be reported to the carrier and to Dana Laboratories immediately.

Prior to performing the checkout procedure, it may be advisable to refer to the Operating Instructions, Section 3.

2.5.1 Zero Check

1. Set FUNCTION control to DC and RANGE to 10.
2. Short input leads. Adjust MV ZERO for zero reading ± 1 digit (000.01).

2.5.2 Polarity Gain Check

1. Set FUNCTION control to DC and RANGE to 10.
2. Apply a known voltage of approximately -10 volts to the input. Visual readout should display value of input voltage and proper polarity indication.
3. Reverse polarity of voltage at input (to approximately +10 volts). Visual readout should again display input voltage and proper polarity.

2.5.3 Range Check

1. Set RANGE to 100.
2. Connect input to a source of +100 volts DC.
3. Visual readout should display input value and proper polarity indication.
4. Vary input voltage and polarity, and check for proper readout.
5. Repeat on 1000 volt range.

Section 3

Operation

3.1 CONTROLS (Figure 3.1)

3.1.1 POWER ON-OFF Switch

This is a pushbutton switch that applies power to the instrument. When Power is ON, the DVM display is always lit. The power switch is independent of both the left-and-right-hand modules. It electrically connects with the power supply at the rear of the instrument.

3.1.2 READ/HOLD Switch

This is a two-position switch that allows the operator a choice of a READ mode, in which new readings are commanded at a fixed rate of four per second, or a HOLD mode, which freezes the last previous reading indefinitely. HOLD is released by turning the switch back to the READ position.

3.1.3 FUNCTION Switch

This is a four-position switch having the following positions:

1. FAST DC. This position selects high-speed, non-filtered DC measurements from 1mV to 1000 volts.

2. DC. This position selects medium-speed DC measurements from 1mV to 1000 volts. An input filter is installed in the circuit in this position.

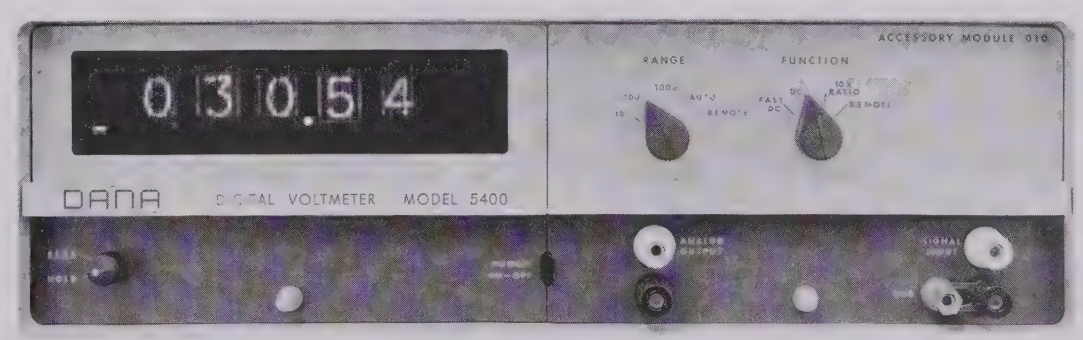


Figure 3.1. Control Panel

3. 10X RATIO. This position selects the measurement of the ratio of the input voltage, applied across the input signal terminals, to a reference voltage, applied to the reference input terminals at the rear of the instrument. A 1:1 ratio is displayed as 10 rather than 1.

3.1.4 RANGE Switch

The RANGE switch has three fixed range positions, an AUTO position, and REMOTE.

FIXED RANGES. The three fixed ranges are 10, 100, and 1000.

AUTO (Automatic.) In this position, range is automatically selected by internal circuits.

REMOTE. In this position, the selection of range is made externally through the Remote Programming input.

3.2 MANUAL OPERATION

The instrument has been designed for the simplest possible level of operation. Once the instrument has been connected to the power line and to the signal source in accordance with the instructions in Section 2, the operator can make all the required measurements by setting the front panel manual controls to the indicated positions.

When switching from one type of measurement to another by turning the FUNCTION control, it is generally advisable to keep the RANGE switch on AUTO so as to avoid overloading the input circuitry.

The digitizing time is so rapid that no bothersome flicker occurs on the digital voltmeter display between the four-per-second readings in the "read" mode. With a constant input signal, the display appears to remain fixed. It is therefore normally most convenient to leave the READ/HOLD control on the READ position, using the HOLD position only for special applications, such as external command operation.

3.2.1 DC Measurements — Fast, Normal, and Millivolt

Attach the high side of the signal source to the white signal input terminal, the low side to the black signal input terminal. Normally the ground terminal (which is at the DVM chassis ground) is jumpered to the black signal input terminal. If the input signal cable has a shield, this should also be attached to the black signal input terminal. To operate the DVM on a floating basis, detach the ground terminal from the black input signal terminal.

3.2.2 Ratio Measurements

Attach the signal input as for the DC instructions above. Attach the +DC reference voltage with the positive side to the white EXT REF terminal on the rear panel of the instrument. The black EXT REF terminal is tied internally to the black signal input terminal, and this is normally jumpered externally to the ground terminal, which is at DVM chassis ground.

Because the black terminals are tied together, the instrument can by itself make only three-wire ratio measurements (i.e., the reference and signal voltages have a joint common). For four-wire ratio measurements, use a differential amplifier, such as the Dana 3400 or 635.

3.3 REMOTE PROGRAMMING

The Digital Voltmeter may be operated by isolated remote contact closures or by a combination of front panel manual controls and remote contact closures. Refer to the "Electrical Output and Programming Option" manual for instructions.

Section 4

Theory Of Operation

4.1 INTRODUCTION

This section covers theory of operation of the 010 Accessory Module. Refer to the basic Digital Voltmeter Manual for theory of operation of the Digitizing and Display Module.

The 010 Accessory Module supplies a 10-volt full scale input voltage to the Digitizing and Display module. This voltage is converted to a precise current and, in the Digitizing and Display module, balanced against a known fraction of a fixed reference current.

The descriptions and simplified diagrams throughout this section are intended to supplement the complete schematics included in Section 6. Logic symbols used in the diagrams are defined in Figure 4.1.

4.2 CIRCUIT DESCRIPTIONS

A general description of each circuit board in the module is followed by an operational description of the measurement of each function.

4.2.1 Control and Attenuator (Schematic 430336)

The Control and Attenuator is the first assembly behind the front panel. On it are mounted the front panel switches and input/output terminals. The board contains relays which switch polarity, function, and range displays; filters, and scaling resistors. The relays are controlled by the function selection — from either the front panel switch or through remote programming — and by the range signals — from either the RANGE switch, through remote programming, or from the Auto Polarity board. The board also carries the logic circuits necessary to translate the local and remote commands into the appropriate relay responses.

Three relays, K1 through K3, are used. One side of each relay coil is tied to +28V; the relay is energized by applying a digital common level to the opposite side. The purpose of each relay is indicated in the following table.

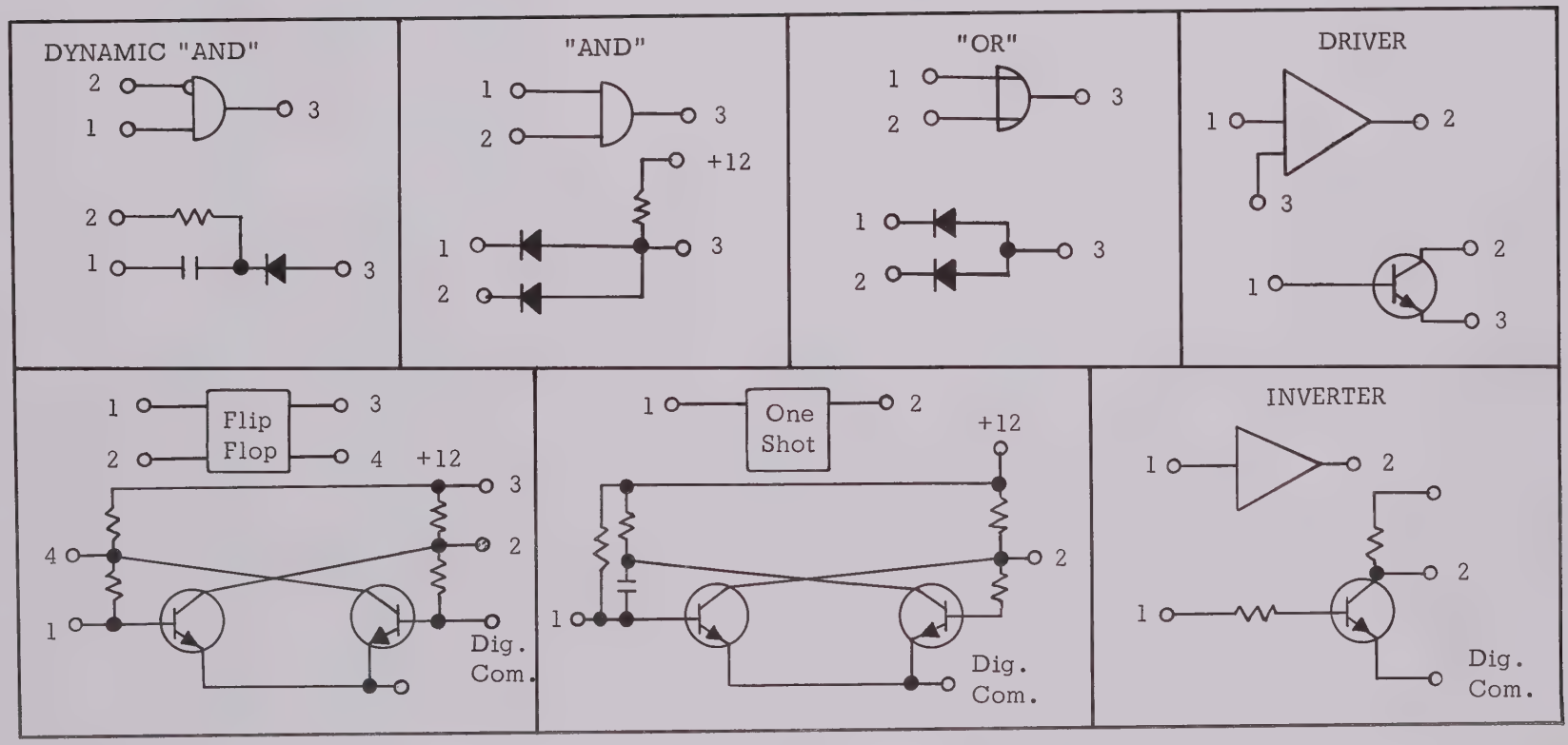


Figure 4.1. Dana Logic Symbols

Relay	Energized by:	Function
K1	DC selected Ratio selected	Installs active filter into the input circuit
K2	R1, R2	Range switching
K3	R2	Range switching

4.2.2 Isolator (Schematic 430305)

The Isolator is a floating-input differential amplifier capable of operating at very low signal levels. The feedback loop, that establishes amplifier gain, is located on the Control and Attenuator board. The feedback circuit and the amplifier unit are switched into various configurations to conform to the function and range selected. The amplifier operates as a unity-gain isolator for DC and ratio. A simplified drawing of the circuit is shown in Figure 4.2.

Operating in conjunction with the Isolator amplifier is a "bootstrap" amplifier (consisting of Q5, Q6, Q10, Q11, and Q15, see schematic). This amplifier samples the voltage at the negative feedback point and adjusts the supply voltages to the input stage so that base and collector voltage remain constant. It also provides a reference level for the first stage base current.

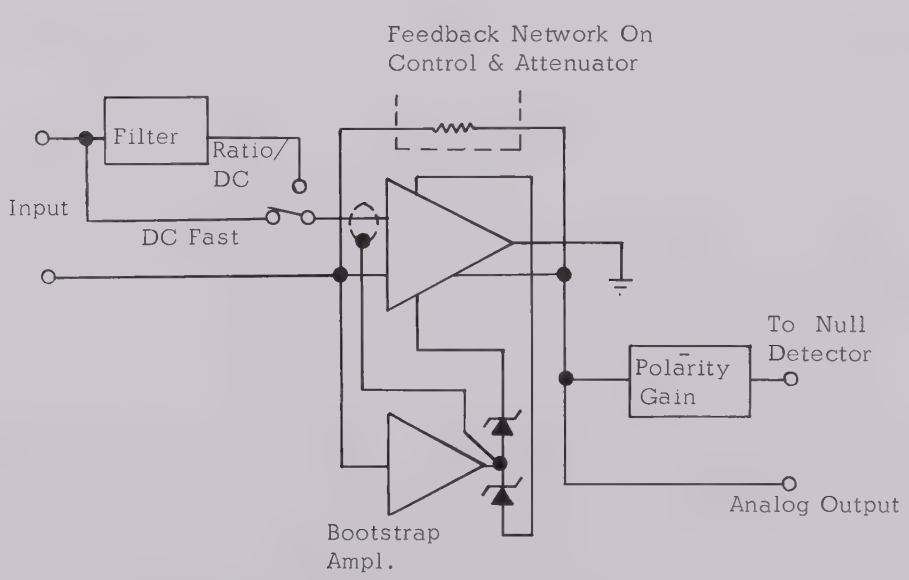


Figure 4.2. Isolator

4.2.3 Auto Range (Schematic 430299)

The Auto Range board consists of a two-stage flip-flop counter which generates the range control signals, R1, R2, and their complements. These signals are sent to the other boards throughout the instrument where they energize the proper range relays. The counter is controlled by signals from the Digitizing and Display module (Decade boards). Full-scale, represented by a count of 10999, causes Count Up Range to be "true"; one-tenth scale, represented by a count of 00999, causes Count Down Range to be "true."

The Count Up Range and Count Down Range signals have no effect on the counter except when the output of the Start/Stop Memory (S/S) one-shot is "true." This occurs when the S/S signal (generated in the Digitizing and Display module) goes "false" at the end of a digitizing process. The counter will count up as shown below.

States		
R1	R2	Range
0	0	10
0	1	100
1	1	1000

Any fixed range, selected either manually or remotely, inhibits the automatic range function. This is done by the logic gate at the S/S Memory output.

4.2.4 Auto Polarity (Schematic 430415)

The Auto Polarity board eliminates the need for polarity switching by maintaining (in conjunction with the Isolator output) a negative input to the Digitizing and Display module regardless of the polarity of the input. A simplified diagram of the Auto Polarity circuit is shown in Figure 4.3. The circuit consists of an inverting amplifier with positive and negative feedback paths. The input resistor and feedback resistors are equal, resulting in unity gain.

The input to the Auto Polarity board from the Isolator is of the same polarity as the input. It is scaled to 10 volts, full scale. A positive input to the Auto Polarity amplifier produces an equal negative voltage on the negative feedback path and zero volts on the positive path; a negative input voltage produces zero voltage on the negative path and an equal positive voltage on the positive feedback path. The input to the Null Detector is taken from only the negative feedback path. Therefore, the voltage at the positive gain trimming resistor is either zero (with negative input) or -10 volts full scale (with positive input).

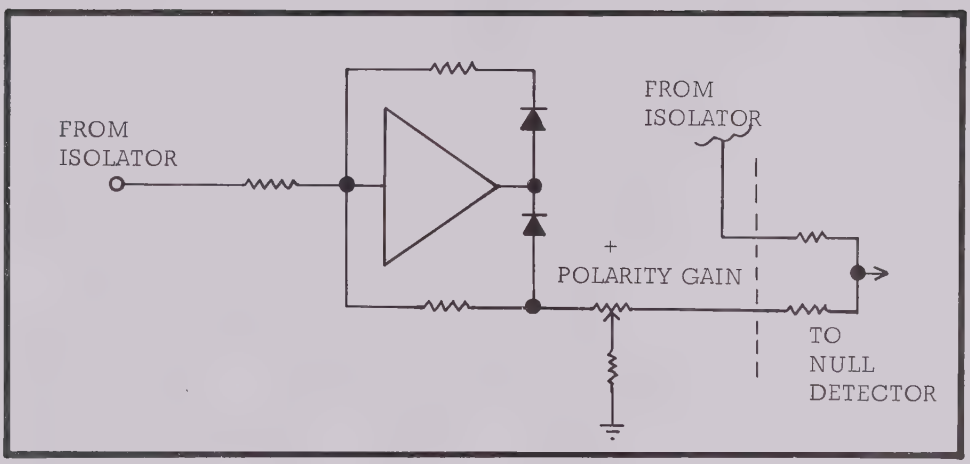


Figure 4.3. Auto Polarity Circuit

4.3 MEASUREMENT OF DC VOLTS AND RATIOS

The circuit configuration used for the measurement of DC volts is shown in Figure 4.4. (Note that the diagram is arranged to show the physical location of the boards. Locations, from left to right, represent module locations from front to rear). An identical arrangement is used when the instrument is in the ratio-measuring mode. The difference in these two types of measurements lies in the counterbalancing reference used in the Digitizing and Display module. DC volts are measured against a fixed internal reference; ratios are measured against an external reference.

As explained previously, the purpose of the accessory module is to produce a negative 10-volt fullscale signal (-10.999, including over-range) at the input of the Digitizing and Display module. The negative voltage is applied across precision resistors ro produce a current that is nulled by an opposite current generated by the reference voltage.

The first step is to scale the incoming DC signal to 10 volts full scale. The precision scaling resistors in the Control and Attenuator circuit divide the input voltage by 10 if the signal is between $\pm$10.999 and $\pm$109.99 volts, and by 100 if the signal is between $\pm$109.99 and $\pm$1,000 volts. The 10-volt full scale input is then filtered to remove superimposed noise and fed into the input of the Isolator. The Isolator is a unit gain amplifier. Its output is therefore identical in polarity

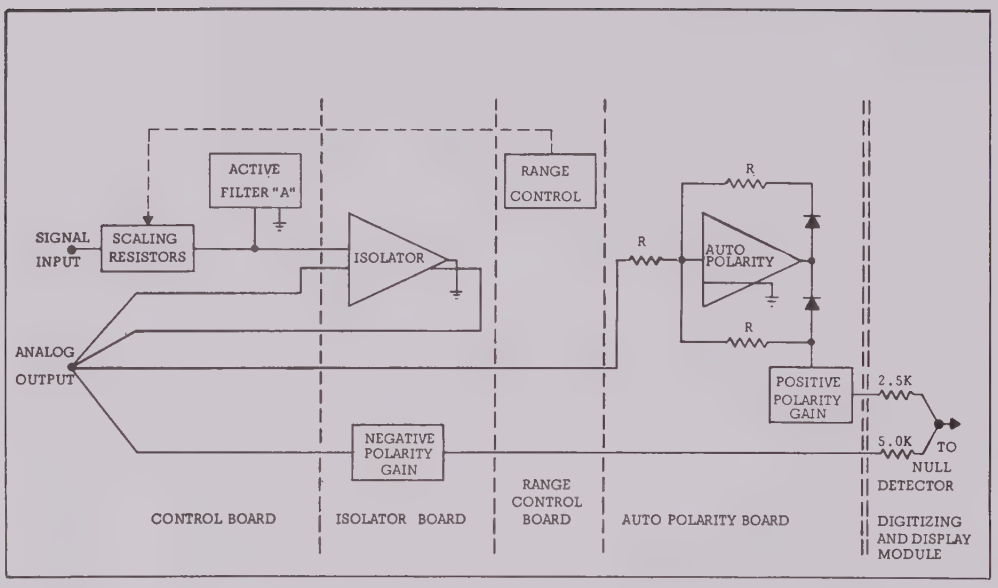


Figure 4.4. Block Diagram - DC Measurement

and amplitude with the scaled input. The voltage is directed in parallel to two destinations: the input to the Null Detector via a 5,000-ohm resistor, and the input to the Auto Polarity amplifier.

As shown in Figure 4.3, only the negative-voltage feedback leg of the Auto Polarity amplifier is used. Since the amplifier is unity gain inverting, a negative voltage equal in amplitude to the Isolator output is present only when the Isolator output is positive. When the Isolator output is negative, there is no signal output from the Auto Polarity amplifier since the positive-voltage loop is carrying the feedback. The Auto Polarity amplifier is connected to the Null Detector input through a 2,500-ohm resistor.

The current into the Null Detector, then, has two potential sources. If the input signal is negative, the Isolator output is negative and the Auto Polarity output is zero, and all of the required negative voltage is from the Isolator. On the other hand, if the input signal is positive, the Isolator output is positive and an equal

negative voltage is generated by the Auto Polarity circuit. However, the resistance on the Auto Polarity leg of the null detector input is only half that of the Isolator. The net is a "negative" current that is precisely the same amplitude as the "positive" current that would be generated by the Isolator voltage alone.

The Auto Polarity amplifier derives its name from the fact that it allows the Null Detector to deal exclusively with negative currents from the Signal Conditioning module, without any delay for polarity switching. This is of particular importance when the instrument is being used in the ratio mode and the signal is frequently passing through zero, as in the case of bridge balancing.

Field calibration includes trimming of the 5,000- and 2,500-ohm resistances at the Null Detector input by adjusting potentiometers on the Isolator and Auto Polarity boards (Polarity Gain adjustments). With a negative standard voltage input, only the Isolator voltage to the Null Detector is involved; the negative Polarity Gain adjustment on the Isolator is therefore calibrated first. When a positive standard-voltage input is applied, both current sources are contributing to the Null Detector input and, since Negative Polarity Gain has already been calibrated, the Positive Polarity Gain on the Auto Polarity board is adjusted for positive input voltages.

It is important to note that the Positive Polarity Gain adjustment is used to calibrate positive input voltages; however, the actual polarity voltage affected by this adjustment is always negative (or zero). By contrast, the Negative Polarity Gain adjustment is dealing with the Isolator output, which may be positive or negative, depending on the polarity of the input signal.

4.4 MEASUREMENT OF FAST DC VOLTS

When fast DC measurements are being made, the configuration of the Signal Conditioning module is the same as for DC measurements except that the Active Filter is removed. Elimination of the filter allows the instrument to settle to within 0.01% of the final reading in 50 milliseconds, after a step-function change in input level. The filter slows the settling time down to 250 milliseconds. Other than this change at the input, the fast DC mode is identical to that of the standard DC and ratio measurements.

Section 5

Calibration

5.1 GENERAL

The procedures in this section are for "field" calibration of the instrument. They are designed to keep the instrument operating within its specifications for indefinite periods of time. Equipment required for the field calibration of the 010 Module is limited to a precision DC voltage source and a set of standard resistors. All adjustments are made on components located in the 101 Module. Access to the components is from the top, requiring that the top cover of the instrument be removed. Figure 5.1 illustrates all of the calibration points involved.

5.2 ZERO CALIBRATION

a. Switch Function Control to DC and range to 10.

b. Short input leads.

c. Adjust Zero Control (through front panel hole) until Model 5400 display reads 000.00.

5.3 MINUS AND PLUS POLARITY GAIN

a. Switch Function Control to DC and range to 10.

b. Connect input leads to known negative voltage near -10 volts.

c. Adjust Minus Polarity Gain adjustment on Isolator Board until Model 5400 display reads value of known voltage.

d. Reverse polarity of input.

e. Adjust Plus Polarity Gain adjustment on Auto Polarity board until Model 5400 display reads value of known voltage.

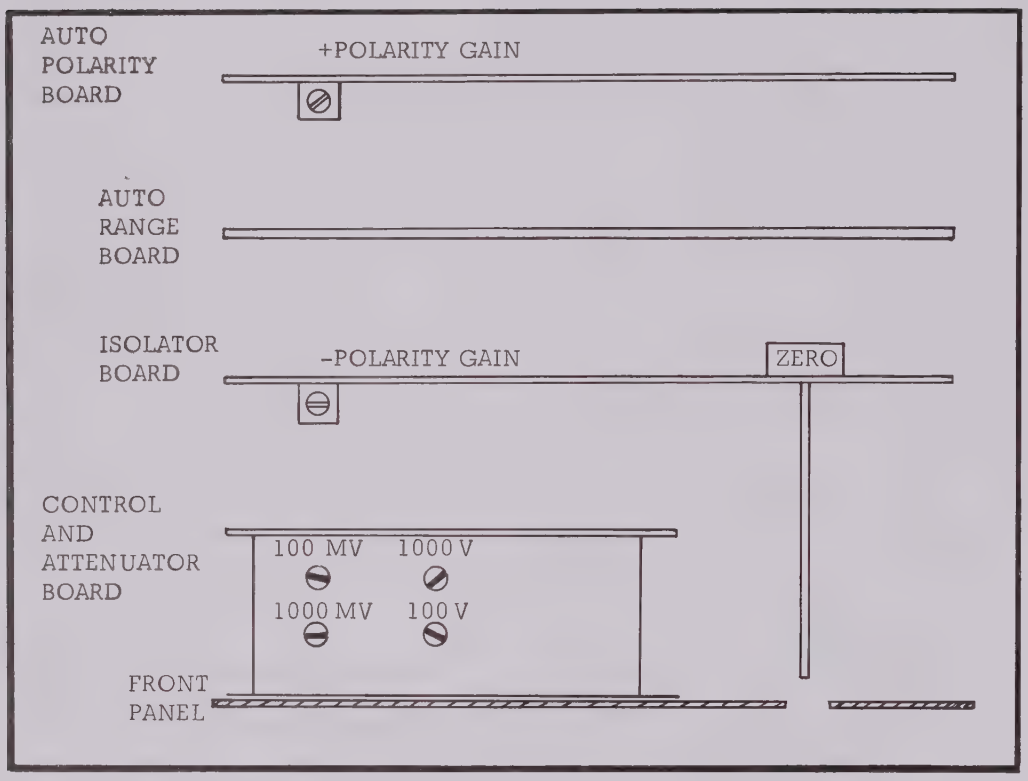


Figure 5.1. Calibration Points - 010 Module

5.4 RANGE CALIBRATION - VOLTS

a. Switch range to 100.

b. Connect input leads to ±100 volt source.

c. Adjust 100 volt range adjustment on Control and Attenuator board until Model 5400 display reads value of known voltage.

d. Switch range to 1000 and repeat first two steps above with ±1000 volt source and 1000 volt range adjustment

Section 6

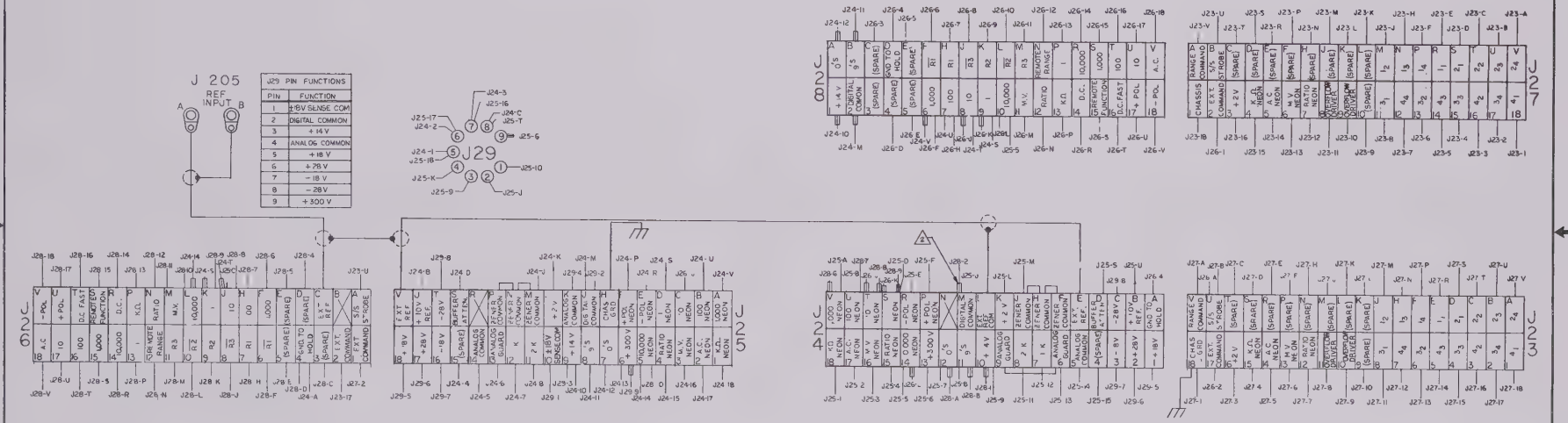
Drawings And Parts List

6.1 DRAWINGS

430311	Wiring Diagram - Interconnection
430362	Wiring Diagram - Model 5400 DVM, BCD Intraconnecting
430417	Wiring Diagram - Intraconnection, Model 010
400783	Attenuator and Control Assembly - Model 010
430336	Schematic Control and Attenuator - Model 010
402192	PC Board Assembly - Attenuator, Model 010
400784	PC Board Assembly - Switch Panel
400700	PC Board Assembly - Isolator
430305	Schematic - Isolator
402198	PC Board Assembly - Auto Range
430502	Schematic - Auto Range
402056	PC Board Assembly - Auto Polarity
430415	Schematic - Auto Polarity

6.2 PARTS LISTS

Parts lists follow the drawings and are arranged in the same sequence in which the drawings appear.



⚠ LEADS INDICATED THUS: CONSIST PARTIALLY OF 22 GA. TINNED BUS WIRE (P/N 500004) INSULATED WITH 20 GA. TEFLON SLEEVING (P/N 501376).

L CONNECTORS SHOWN AS VIEWED FROM REAR OF INSTRUMENT; THUS J23, J24, J25 & J26 ARE ON FAR SIDE OF INTERCONNECTION BOARD; J27, J28 & J29 ARE ON NEAR SIDE.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS / ANGLES
.X ± .030 / ± 0° 30'
.XX ± .020
.XXX ± .010
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	W. Eoff	20 Oct 1969
CHK	T. Lof	10 NOV 1969
APPD	J. Hall	10 NOV 1969

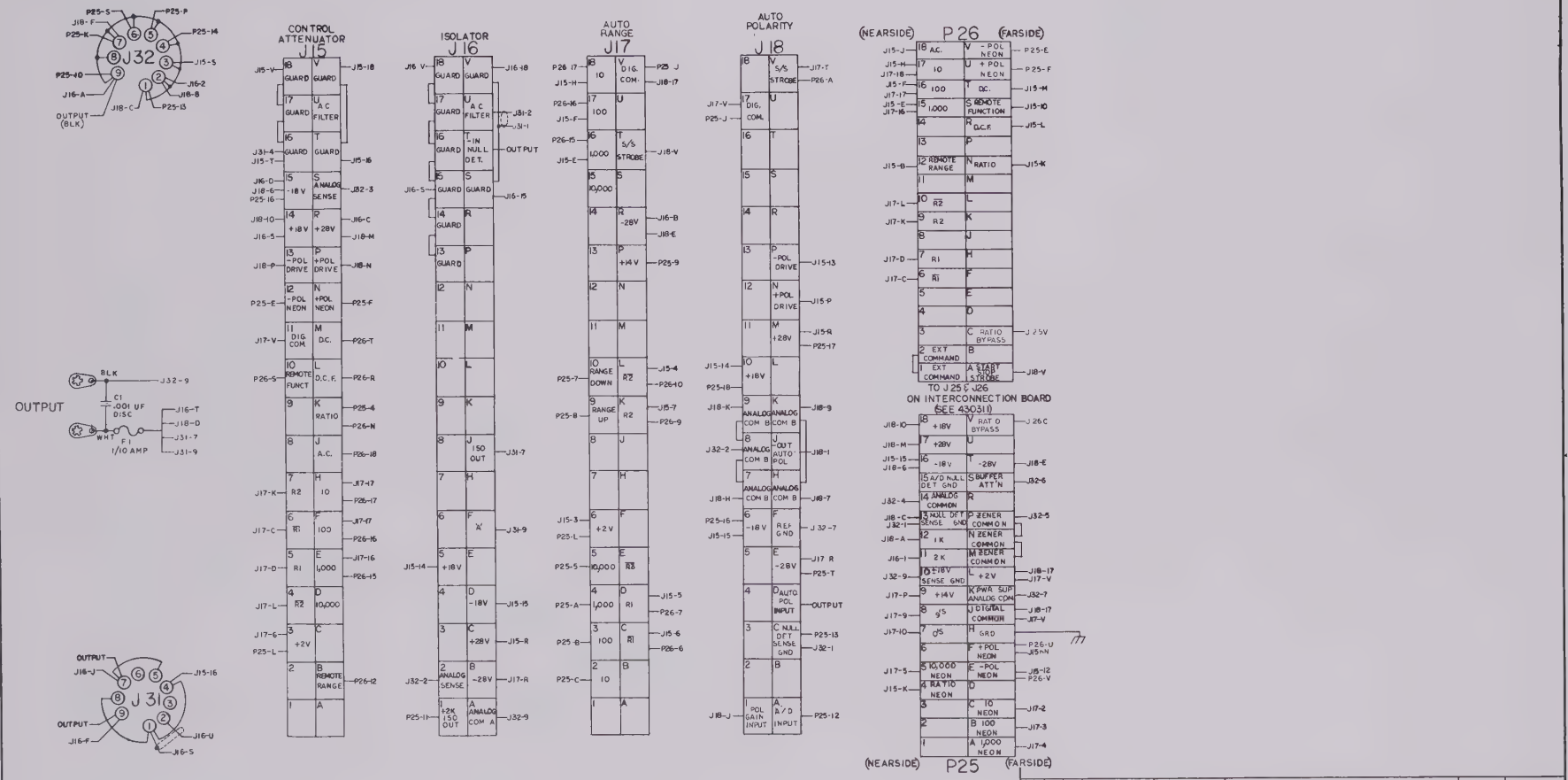
DSR 11-17-69
DSR 11-18-69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

WIRING DIAGRAM - INTERCONNECTION

SIZE	CODE IDENT NO.	DWG NO.	
D	—	430311	H

SCALE — | WT — | SHEET 1 OF 1



QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ±.030, XX ±.020, XXX ±.010; ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	[illegible]	6-4-66
CHK	[illegible]	8 June 66
APPD	[illegible]	6-8-66

Rel. 7.1.66
PRN 2d 4708 D

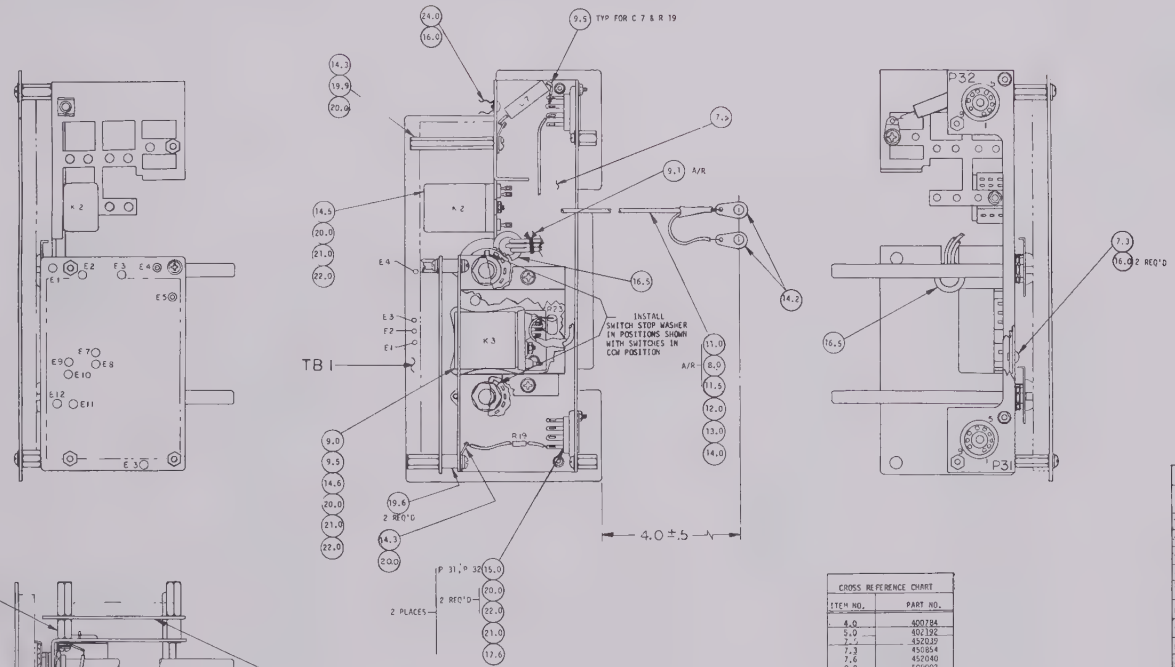
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

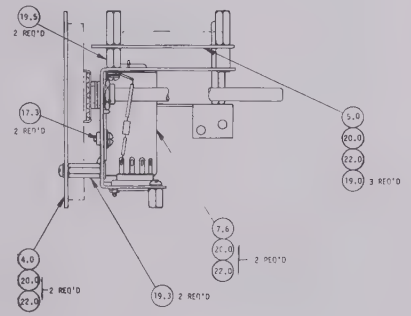
WIRING DIAGRAM— INTRACONNECTION, 010

SIZE	CODE IDENT NO.	DWG NO.	
D	21793	430417	D

SCALE | WT | SHEET 1 OF 1

1 CONNECTORS VIEWED FROM WIRING (DIP PIN) SIDE
NOTES: UNLESS OTHERWISE SPECIFIED





R 23	1.0	887 K 1%
R 19	.5	100K 1/4 W
P 32	15.0	Socket- 9 Pin
P 31	15.0	Socket - 9 Pin
K 3	2.0	Relay - (4 FORM c)
K 2	1.6	Relay - 2 POLE
C 7	1.3	.015 mfd 100 V
REF DES	B/M ITEM	DESCRIPTION

CROSS REFERENCE CHART

ITEM NO.	PART NO.
4.0	400784
5.0	402192
7.2	432039
7.3	450854
7.6	452040
8.0	500002
9.0	500004
9.1	500005
9.5	501376
11.0	501446
11.5	524002
12.0	524920
13.0	524921
14.0	524922
14.2	600026
14.3	600032
14.5	600221
14.6	600222
15.0	600232
16.0	610019
16.5	610027
17.3	610111
17.6	610118
19.0	610240
19.3	610251
19.5	610256
19.6	610257
19.9	610263
20.0	615042
21.0	617016
22.0	617027
24.0	920113

WIRE LIST

FROM	TO	CONDUCTOR USED; COLOR	WIRE LENGTH	B/M ITEM NO.	NOTES	LINE
TB1 - E 1	K 2 - 4				Via grommet (Item 16.5)	1
TB1 - E 2	K 3 - 1				Via grommet (Item 16.5)	2
TB1 - E 3	K 2 - 1				Via grommet (Item 16.5)	3
TB1 - E 4(K1) Shld.not conn	P 31 - 2 Shld. to P 31 - 4	RG 174/U		11.0	Via grommet (Item 16.5)	4
K 2 - 4	K 3 - 4					5
K 2 - 5	TB2 - E4					6
K 2 - 6	K 3 - 8					7
K 2 - 7	TB2 - E5					8
TB2 - E6	K 3 - 11					9
TB2 - E5	K 3 - 16				K3-16 USED AS JUNCTION POINT	10
P 31 - 1	#4 Grnd Lug (Item 14.3)	R 19	---	.5	100 K, 1/4 W, 5%	11
P 31 - 3 Shld.to P31-1	K 3 - 9 Shld.not conn	RG 174/U		11.0		12
K 3 - 6	K 3 - 10	SLEEVED BUSS WIRE				13
K 3 - 7	K 3 - 16	R 23	---	1.0	K3-16 USED AS JUNCTION POINT LEAD SLEEVED AS REQ'D	14
K 3 - 12	P 32 - 3					15
K 3 - 16 Shld.to P32-2	#10 Grnd Lug (Item 14.2) BLK	RG174/U			K3-16 USED AS JUNCTION POINT	16
P 31 - 1	#4 Grnd Lug (Item 14.3)	C 7	---	1.3	LEADS SLEEVED AS REQ'D	17

RELAY TERMINAL LAYOUTS

K2

K3

3. SCHEMATIC REFERENCE: 430336
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
1. WIRING DIAGRAM REFERENCE 430336

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL
APPLIED FINISH
HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ±.030, XX ±.020, XXX ±.010
ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

NAME	DATE
DR	10 FEB 1966
CHK	24 FEB 1966
APPD	1 MAR 1966

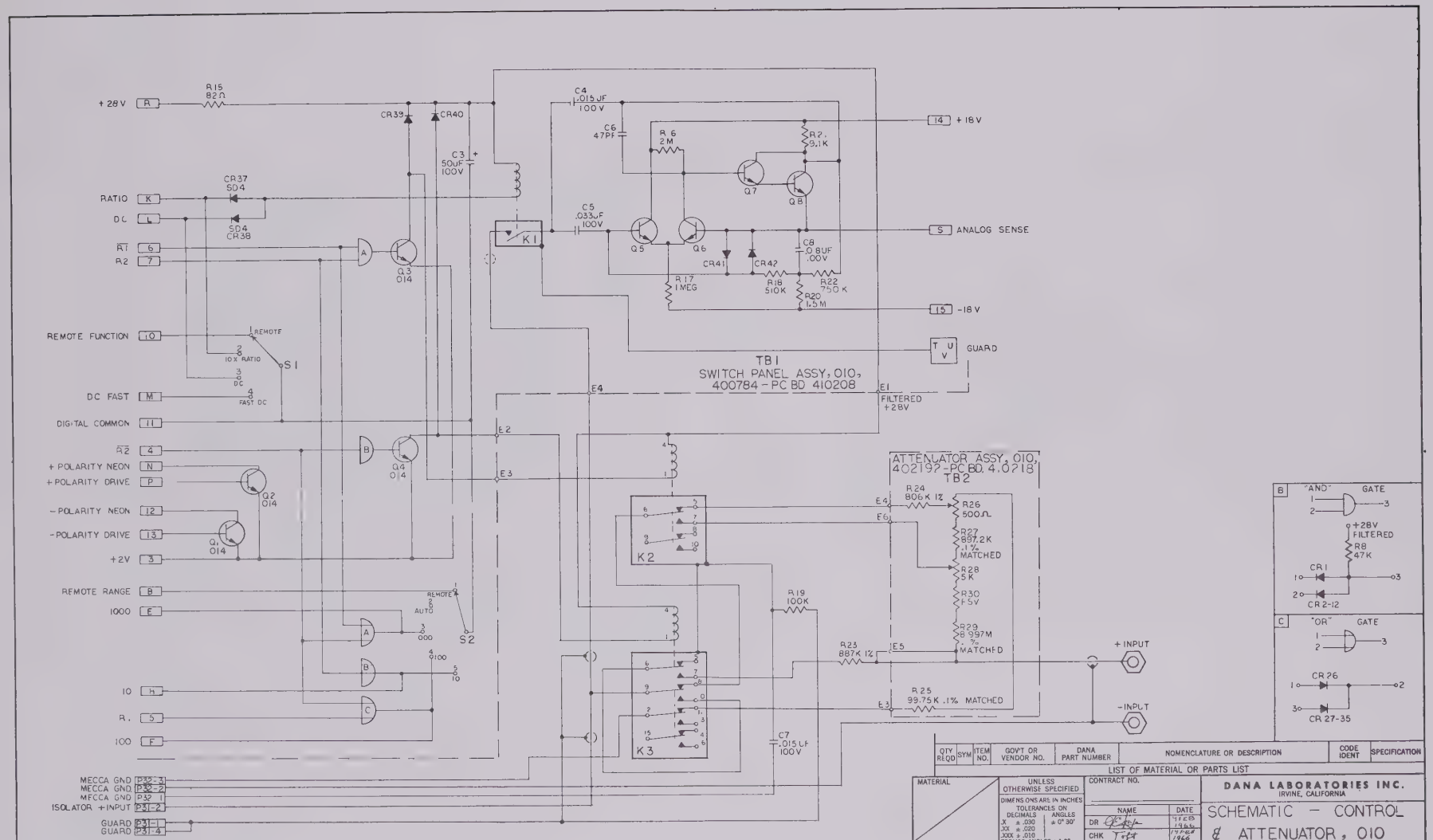
Rev 7-1-66
DANA 4718B

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

CONTROL & ATTENUATOR ASSY — 010

SIZE	CODE IDENT NO.	DWG NO.	
D	———	400783	J

SCALE 1 / 1 WT ——— SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. All resistors 1/4W, 5%, Carbon
2. All diodes 018
3. All transistors 2N3565
4. All voltages referenced to digital common
5. Highest lettered reference designator are: C-8; CR 42; R 30; Q 8; S 2; K 3
6. Highest letterer reference designators for logic elements appear in left hand corner of logic schematic.

QTY REQD	SYM	ITEM NO.	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL
APPLIED FINISH
HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: .X ±.030; .XX ±.020; .XXX ±.010
ANGLES ±0° 30'
FORMED ANGLES ±1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

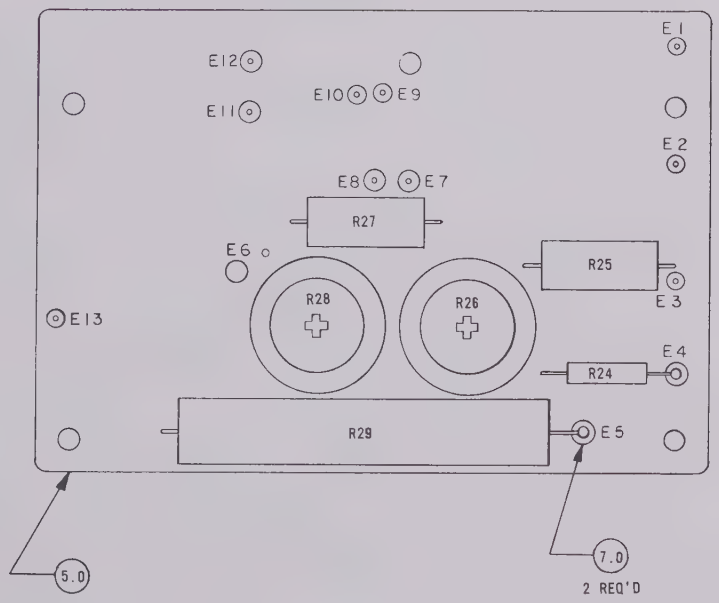
NAME	DATE
DR	11 FEB 1966
CHK	14 FEB 1966
APPD	21 FEB 1966

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC — CONTROL & ATTENUATOR, 010

SIZE	CODE IDENT NO.	DWG NO.	
D		430336	B

SCALE — WT — SHEET 1 OF 1



CROSS REFERENCE CHART	
ITEM NO.	PART NO.
5.0	410218
7.0	600243

REF DES	B/M ITEM	DESCRIPTION
R 29	2.0	8.997M .25 MATCHED SET
R 28	3.0	5K (POT)
R 27	2.0	897.2K .25% MATCHED SET
R 26	4.0	500 OHM (POT)
R 25	2.0	99.75 .25% MATCHED SET
R 24	1.0	806K 1% RN65

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
1. RESISTORS TO BE ¼W, CARBON, 5%.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES

TOLERANCES ON

DECIMALS	ANGLES
.X ± .030	± 0° 30'
.XX ± .020	
.XXX ± .010	

FORMED ANGLES ± 1.0°

ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

NAME	DATE
DR JIM AREALI	9-13-1966
CHK L. Hanssen	10-1-66
APPD	12/9/66

Format 1 Rl. 490

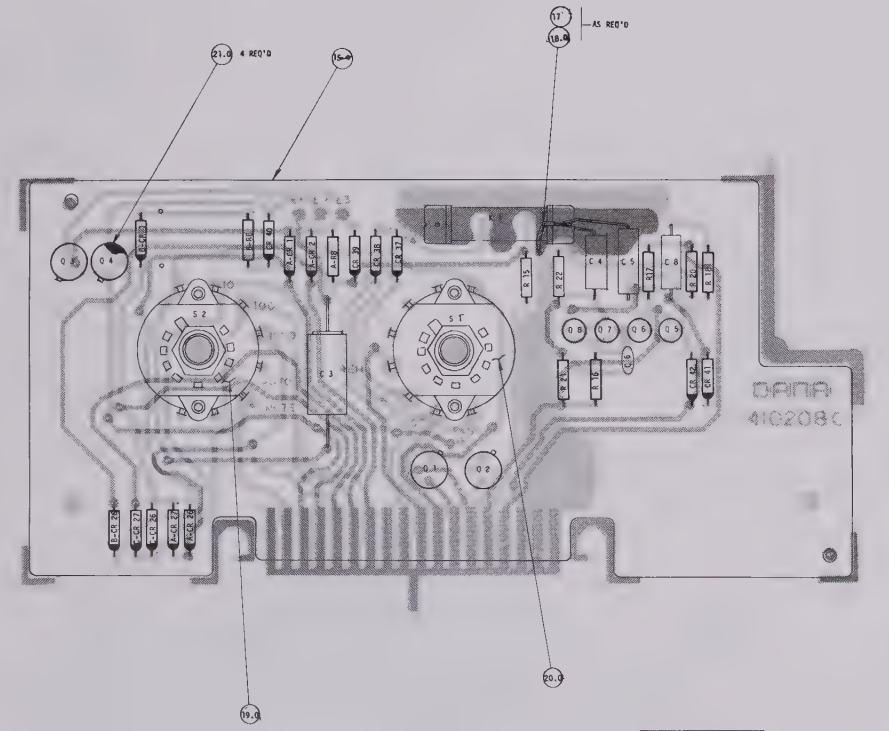
" 76

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASS'Y.— ATTENUATOR 010

SIZE	CODE IDENT NO.	DWG NO.	
C	—	402192	A

SCALE 2/1 | WT — | SHEET 1 OF 1



REF DES	B/M ITEM	DESCRIPTION
Q 4 THRU Q 1	9.6	014
K 1	14.0	Relay
CR 42	13.0	018
CR 41	13.0	018
CR 40	13.0	018
CR 39	13.0	018
CR 38	12.0	SD 4
CR 37	12.0	SD 4
C-CR26	13.0	018
C-CR27	13.0	018
B-CR26	13.0	018
B-CR27	13.0	018
A-CR26	13.0	018
A-CR 2	13.0	
B-CR 1	13.0	
A-CR 1	13.0	
C 8	8.4	.018 MFD 100V
C 6	6.0	47 pf
C 5	8.5	.033 MFD 100V
C 4	8.4	.015 MFD 100V
C 3	7.0	50 MFD 50V

REF DES	B/M ITEM	DESCRIPTION
S 2	19.0	600218
S 1	20.0	600236
R 22	4.7	750K
R 21	5.0	9.1 K
R 20	2.0	1.5 MEG
R 18	4.6	510 K
R 17	1.0	1 Meg
R 16	4.0	2 Meg
R 15	4.8	82 ohms
B-R 8	4.5	47 K
A-R 8	4.5	47 K
Q 8 THRU Q 5	10.0	2N3565

CROSS REFERENCE CHART	
ITEM NO.	PART NO.
15.0	410208 C
17.0	500004
18.0	501376
19.0	600218
20.0	600236
21.0	925006

QTY REQD	SYM	ITEM NO.	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ± .030, XX ± .020, .XXX ± .010
ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D 1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	W. E. Doe	10 FEB 1966
CHK	Tost	16 FEB 1966
APPD		

DWG 6-30 66
DRN 46-368

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

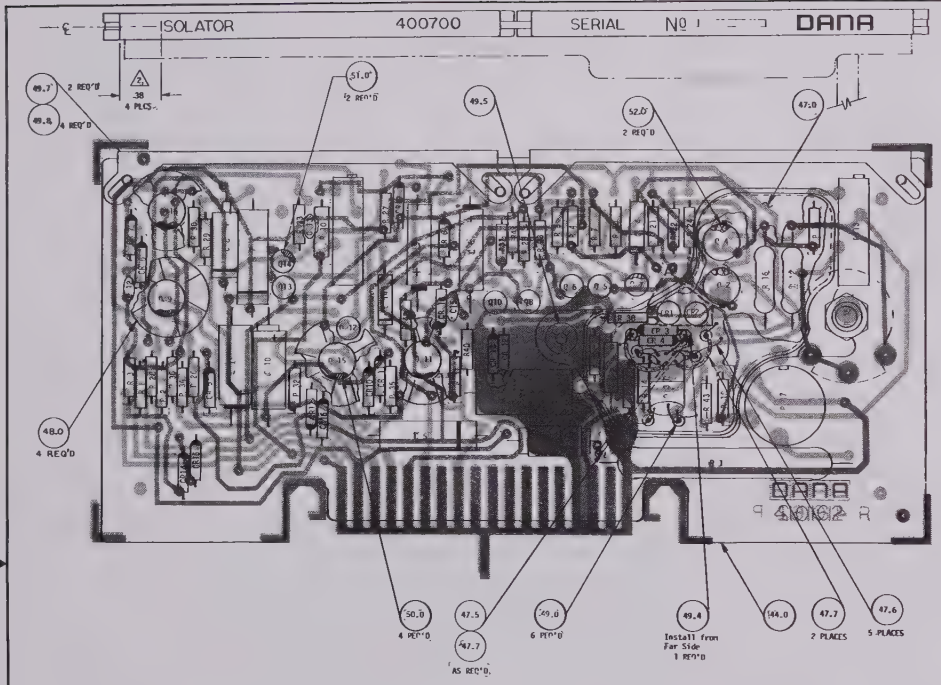
PC BOARD ASS'Y- SWITCH PANEL, 010

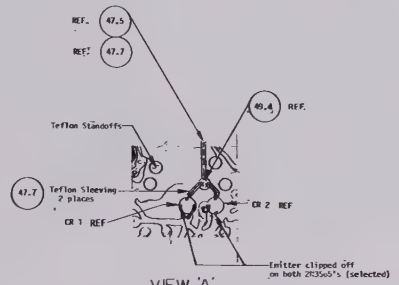
SIZE	CODE IDENT NO.	DWG NO.	
D		400784	D

SCALE 2/1 | WT ——— | SHEET 1 OF 1

3. SCHEMATIC REFERENCE: 430336
2. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
1. Resistors to be 1/4W, carbon, ±5%.

NOTES: UNLESS OTHERWISE SPECIFIED





VIEW 'A'
BOTTOM VIEW OF P.C. BOARD.

CROSS REFERENCE CHART	
ITEM NO	PART NO
44.0	410162 R
47.0	450879
47.5	500004
47.6	500037
47.7	501376
48.0	600016
49.0	600030
49.4	600243
49.5	610087
49.7	610236
49.8	610237
50.0	920006
51.0	920007
52.0	920082

			R34	12.8	510 OHMS			
			R33	9.7	3.3K			
			R32	13.0	51K			
			R31	4.9	1 2K			
CR19	43.5	1/4W2.4AZ10	R30	17.0	75 OHMS			
CR17	41.0	SD4	R29	9.3	24 OHMS			
CR16	41.0	SD4	R28	20.0	9.1K			
CR15	42.0	018	R27	20.0	9.1K	Q16	35.0	014
			R26	8.0	15K	Q15	35.0	014
CR10	42.0	018	R25	11.0	43K	Q14	33.8	012
CR9	43.0	IN958B	R24	2.0	1K	Q13	39.0	2N3565
CR8	42.0	018	R23	10.0	3.3 MEG	Q12	39.0	2N3565
CR7	42.0	018	R22	10.5	39K	Q11	33.0	009
CR6	43.0	IN958B	R21	20.0	9.1K	Q10	39.0	2N3565
CR5	42.0	018	R20	2.0	1K	Q9	35.0	014
CR4	42.3	007				Q8	39.0	2N3565
CR3	42.3	007	R18	18.0	7.5K	Q7	33.8	012
CR2	39.5	200048	R17	23.0	5K POT	Q5	39.1	200044 MATCHED PAIR
CR1	39.5	200048	R16	21.0	4.99 MEG,1%		39.1	200044
C15	25.7	100 PF	R15	24.0	250K POT	Q4	39.8	200063 SELECTED 018
C14	31.8	.01UF/100V	R14	10.0	3.3 MEG	Q3	40.0	2N1304
C13	25.7	100PF DISC	R13	25.0	500K POT	Q2	39.8	200063 SELECTED 018
C12	25.5	15PF DISC	R12	21.0	4.99 MEG,1%	Q1	36.0	015
C11	26.0	25UF 50V	R11	5.0	120K			
C10	26.0	25UF 50V	R10	22.2	49.9 OHMS, 1%			
C9	27.0	50UF 12/15V	R9	9.5	2.4K	R43	20.5	FSV
C8	28.0	5UF 50V	R8	1.0	100 OHMS	R42	1.0	100 OHMS
C7	29.0	.1UF 100V	R7	4.4	1 2K	R41	11.5	4.7K
C6	27.0	50UF 12/15V	R6	22.8	5K POT	R40	8.0	15 k
C5	29.0	.1UF 100V	R5	16.9	6.2K	R39	5.3	1.3K
C4	31.0	.001UF 100V	R4	4.0	1.2K	R38	5.5	13 MEG
C3	30.0	2.0UF 100V	R3	1.0	100 OHMS	R37	15.0	5.6 MEG
C2	32.0	.0047UF 100V	R2	16.1	62K	R36	9.3	24 OHMS
C1	30.5	750 PF 500V	R1	22.0	25 MEG,1%	R35	1.0	100 OHMS
REF DES	B/M ITEM	DESCRIPTION	REF DES	B/M ITEM	DESCRIPTION	REF DES	B/M ITEM	DESCRIPTION

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL
APPLIED FINISH
HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ± .030, XX ± .020, XXX ± .010; ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR		
CHK		
APPD		

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

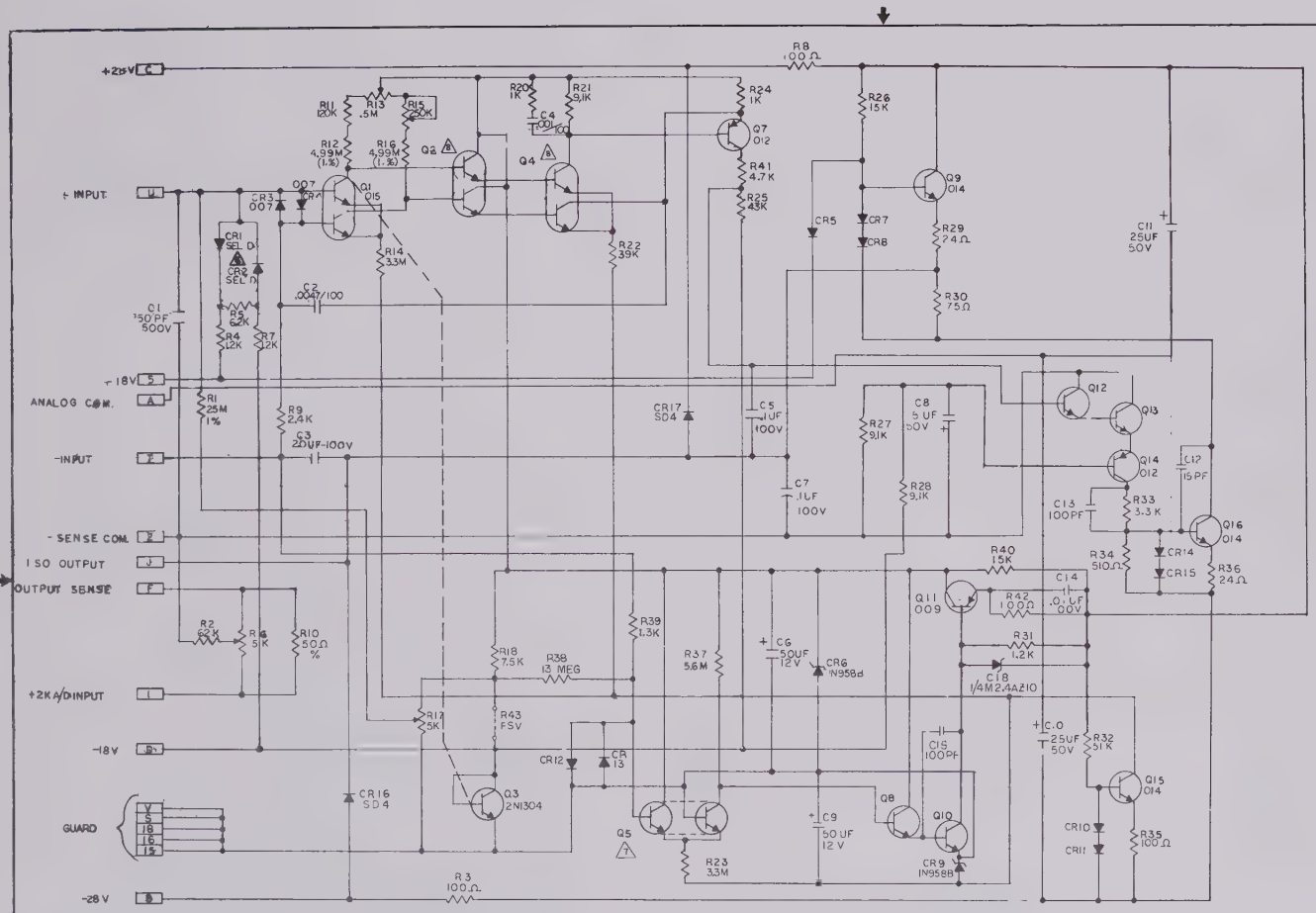
P C BOARD ASS'Y -
ISOLATOR

SIZE	CODE IDENT NO.	DWG NO.	
D		400700	W

SCALE / : / | WT | SHEET / OF /

4. SCHEMATIC REFERENCE: 438205
3. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
2. HEAT STAMP .10 HIGH BLACK CHARACTERS AND .15 HIGH LOGO, LOCATED AS SHOWN.
1. ALL RESISTORS TO BE 1/4 W, ± 5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED



TRANSISTOR - SELECTED Q16 DUAL, P/N 200063 (Q2, Q4)

TRANSISTOR - MATCHED PAIR OF 2N3565, P/N 200044, Q5

CR 1 & CR 2 are DANA P/N 200048; selected @ 3565.

8. Highest numbered reference designators:

R43	Q16
C18	CR18

4. All voltages referenced to analog common
3. All transistors 2N3565
4. All resistors 1/4W, 5%, carbon.
1. All diodes DTF

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ± .030, XX ± .020, XXX ± .010; ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D 1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	[illegible]	9-4-65
CHK	Hans C.	10-4-65
APPD	Barry Hillette	10-6-65

REV 6.22.66
DRAWING 38 PB

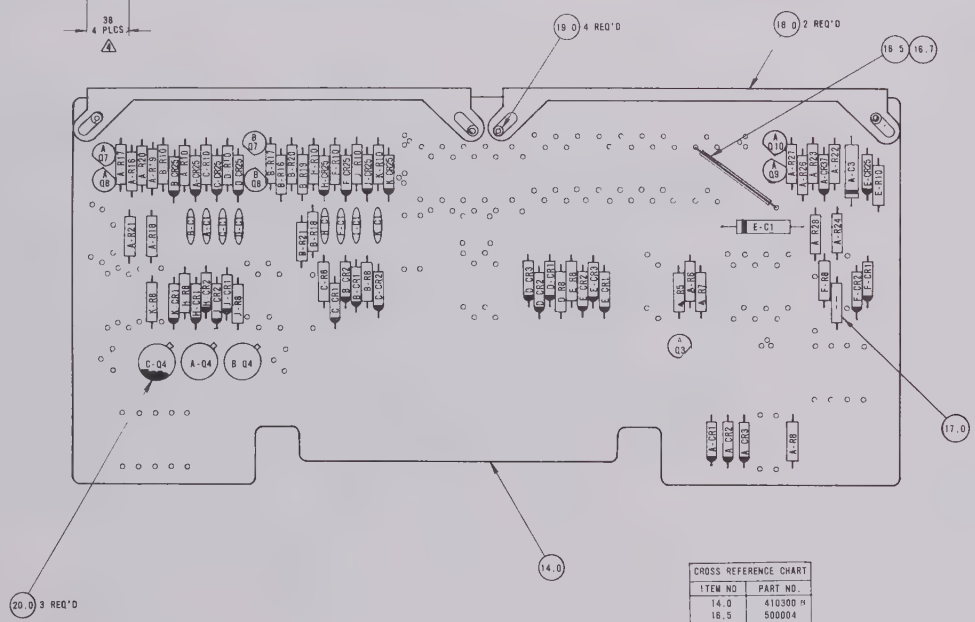
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC —
ISOLATOR

SIZE	CODE IDENT NO.	DWG NO.	
D	—	430305	T

SCALE — WT — SHEET 1 OF 1

AUTO RANGE 402198 SERIAL Nº DANA



CROSS REFERENCE CHART	
ITEM NO	PART NO.
14.0	410300 M
16.5	500004
16.7	501376
17.0	600245
18.0	610238
19.0	610237
20.0	920006

REF DES	B/M ITEM	DESCRIPTION
R 21	6.0	5.1K
R 20	2.0	15K
R 19	4.0	2.2K
R 18	6.0	5.1K
R 17	2.0	15K
R 16	4.0	2.2K
R 10	5.0	27K
⚠5 R 8	5.0	24K
R 7	3.0	200K
R 6	2.0	15K
R 5	7.0	8.2K
Q 10	10.0	2N3565
Q 9	10.0	2N3565
Q 8	10.0	2N3565
Q 7	10.0	2N3565
Q 4	11.0	014
Q 3	10.0	2N3565
CR37	13.0	018
CR25	13.0	018
ACR3	12.0	SD4
ACR2	12.0	SD4
ACR1	12.0	SD4
⚠5 CR 3	13.0	018
CR 2	13.0	018
CR 1	13.0	018
C 3	9.0	.0022UF / 100V
⚠5 E-C1	9.0	.0022UF / 100V
⚠5 C 1	8.0	001UF DISC

REF DES	B/M ITEM	DESCRIPTION
E-R8	6.0	5.1K
⚠5 D-R8	6.0	5.1K
R28	8.0	5.1K
R27	2.0	15K
R26	7.0	8.2K
R24	1.0	100K
R23	7.0	8.2K
R22	5.0	24K

7. SCHEMATIC REFERENCE: 430502.
6. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.
⚠5 COMPONENTS WITH LETTER PREFIX ARE EXCEPTIONS TO THE STANDARD LOGIC.
⚠4 HEAT STAMP .10 HIGH BLACK CHARACTERS AND .15 HIGH LOGO, LOCATED AS SHOWN.
3. ALL TRANSISTORS ARE 2N3565.
2. ALL DIODES ARE 018.
1. ALL RESISTORS ARE ¼W, CARBON, ±5%.

NOTES: UNLESS OTHERWISE SPECIFIED.

NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS X .030 XX .020 XXX .010 | ANGLES 0° 30' | FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN A CHAUSSEE 9-14-66
CHECK [illegible] 9-15-66
COG ENGR
PROJ ENGR D Payne

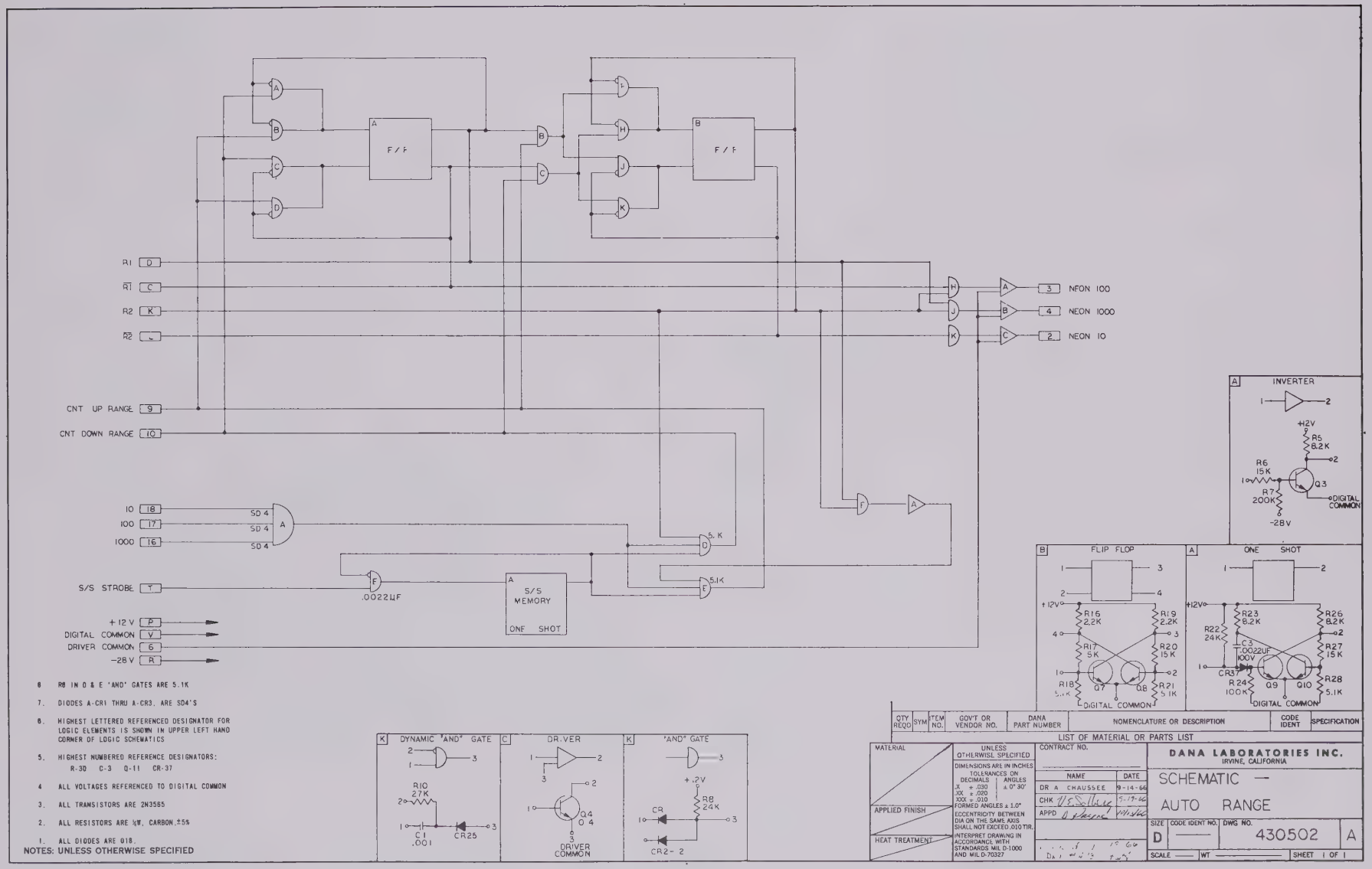
Released 10-19-66 [illegible]

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASSY, AUTO RANGE

SIZE	CODE IDENT NO.	DWG NO.	REV
D		402198	D

SCALE 2:1 WT SHEET 1 OF 1



8. R8 IN D & E "AND" GATES ARE 5.1K
7. DIODES A-CR1 THRU A-CR3, ARE SD4'S
6. HIGHEST LETTERED REFERENCED DESIGNATOR FOR LOGIC ELEMENTS IS SHOWN IN UPPER LEFT HAND CORNER OF LOGIC SCHEMATICS
5. HIGHEST NUMBERED REFERENCE DESIGNATORS: R-30 C-3 Q-11 CR-37
4. ALL VOLTAGES REFERENCED TO DIGITAL COMMON
3. ALL TRANSISTORS ARE 2N3585
2. ALL RESISTORS ARE ½W, CARBON, ±5%
1. ALL DIODES ARE 018.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL
APPLIED FINISH
HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ± .030, XX ± .020, XXX ± .010; ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL D-1000 AND MIL D-70327

CONTRACT NO.

NAME	DATE
DR A CHAUSSEE	9-14-66
CHK W E Sellers	5-17-66
APPD D Hauser	11/15/66

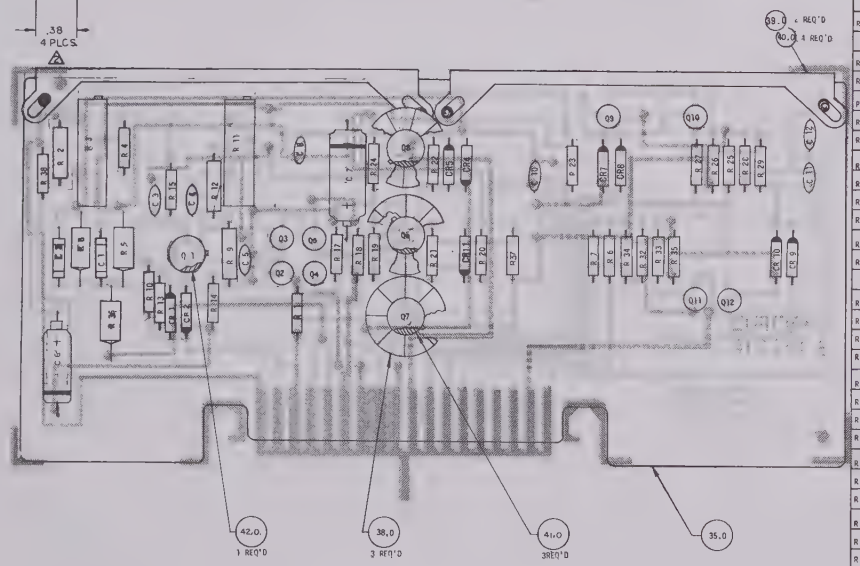
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC —
AUTO RANGE

SIZE	CODE IDENT NO.	DWG NO.	
D	—	430502	A

SCALE — WT — SHEET 1 OF 1

AUTO POLARITY 402056 SERIAL NO. DANA



REF DES	B/M ITEM	DESCRIPTION
R 29	3.0	15 K
R 27	3.0	15 K
R 26	5.0	18 K
R 25	3.0	15 K
R 24	13.0	47 ohms
R 23	7.0	200 ohms
R 22	2.0	10 K
R 21	15.0	91 ohms
R 20	16.0	4.7 K
R 19	15.0	91 ohms
R 18	19.0	4.7 K
R 17	1.0	1 K
R 15	1.0	1 K
R 14	6.0	180 K
R 13	6.0	180 K
R 12	16.0	422 K (1%)
R 11	20.0	50 K (POT.)
R 10	1.0	1 K
R 9	16.0	422 K (1%)
R 8	18.0	10 K (.05%)
R 7	9.0	24 K
R 6	9.0	24 K
R 5	18.0	10 K (.05%)
R 4	12.0	39 K
R 3	19.0	5 K (POT.)
R 2	17.0	100 ohms (1%)
P 1	8.0	2 K

REF DES	B/M ITEM	DESCRIPTION
C 8	22.0	100 pf
C 7	23.0	25 MFD 50V
C 6	24.0	5 MFD 50 V
C 5	22.0	100 pf
C 4	22.0	100 pf
C 3	22.0	100 pf
C 2	26.0	24 pf
C 1	26.0	24 pf
CR 1	34.0	1/4 M2.4 A25
CR10	33.0	018
CR9	33.0	018
CR 7	33.0	018
CR 6	33.0	018
CR 5	32.0	S 322
CR 4	32.0	S 322
CR 2	33.0	018
CR 1	33.0	018
R38	9.5	27 K
R 37	11.0	390 OHMS
R 36	18.0	10 K (.05%)
R 35	10.0	30 K
R 34	4.0	16 K
R 33	10.0	30 K
R 32	4.0	16 K

REF DES	B/M ITEM	DESCRIPTION
Q 12	29.0	2N3646
Q 11	29.0	2N3646
Q 10	31.0	2N3565
Q 9	31.0	2N3565
Q 8	28.0	014
Q 7	28.0	014
Q 6	27.0	009
Q 5	29.0	2N3646
Q 4	29.0	2N3646
Q 3	31.0	2N3565
Q 2	31.0	2N3565
Q 1	31.5	016 SELECTED
C 12	21.0	330 pf
C 11	21.0	330 pf
C 10	22.0	100 pf

CROSS REFERENCE CHART	
ITEM NO	PART NO.
35.0	410241B
38.0	600016
39.0	610236
40.0	610237
41.0	920006
42.0	920082

4 SCHEMATIC REFERENCE: 430415

3: ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.

2 Mark stamp .10 high black characters and .15 high logo, located as shown.

1. All resistors are 1/4W, 5% carbon.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOV'T OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ± .030, XX ± .020, XXX ± .010 | ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	[illegible]	6 JUNE 1966
CHK	[illegible]	9 JUNE 1966
APPD	[illegible]	6/9/66

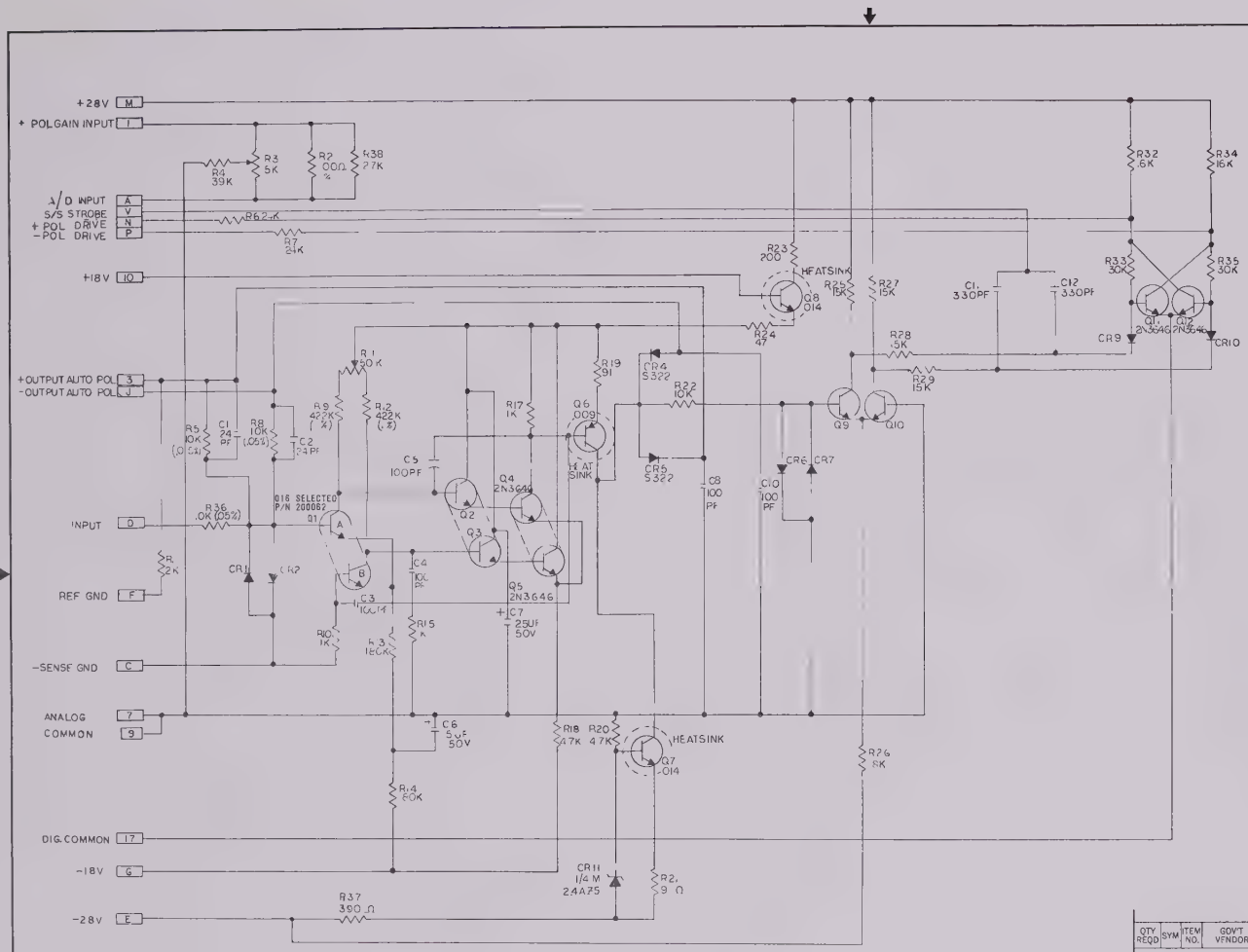
Rel 6-22-66
DRN # 402056

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASS'Y
AUTO POLARITY

SIZE	CODE IDENT NO.	DWG NO.	
D	—	402056	K

SCALE — WT — SHEET 1 OF 1



5. Highest numbered reference designators

R38	D12
C12	C R11

4. All voltages referenced to analog common
3. All transistors 2N3645
2. All resistors 1/4W, 5%, carbon
1. All diodes 018

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	SYM	ITEM NO.	GOVT OR VENDOR NO.	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

MATERIAL

APPLIED FINISH

HEAT TREATMENT

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X ±.030, XX ±.020, XXX ±.010; ANGLES ± 0° 30'
FORMED ANGLES ± 1.0°
ECCENTRICITY BETWEEN DIA ON THE SAME AXIS SHALL NOT EXCEED .010 TIR.
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS MIL-D-1000 AND MIL-D-70327

CONTRACT NO.

	NAME	DATE
DR	[illegible]	4 61
CHK	T. [illegible] T.	9 JUNE 1966
APPD	[illegible]	6/1/66

Rev 6-2-66
TWB 9408.B

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC —
AUTO POLARITY

SIZE	CODE IDENT NO.	DWG NO.	
D	—	430415	E

SCALE — WT — SHEET 1 OF 1

CONTROL AND ATTENUATOR ASSEMBLY - 400783

P A R T S L I S T

REF DES	DANA P/N	PART	TYPE	DESCRIPTION	MANUFAC	MANUFAC P/N
C7	120003	CAP	MYLAR	.1 MFD 100 V 10%	CDE	WMF1P1
K2	310021	RELAY	DC	2 PDT 24V	ALLIED	AZ42056105
K3	310030	RELAY	DC	4 PDT 28V	PARELCO	INR10-E046
P31	600232					
P32	600232					
R19	000104	RES	CARBON	100 K 5% 1/4 W	OHMITE	RC07GF104J
R23	010164	RES	METAL	887 K 1% 1 W	ELECTRA	RN70D8873F

PC BOARD ASSEMBLY ATTENUATOR 010 - 402192

P A R T S L I S T

REF DES	DANA P/N	PART	TYPE	DESCRIPTION			MANUFAC	MANUFAC P/N
R24	010165	RES	METAL	806 K	1%	1/2 W	ELECTRA	RN65D8063F
R25	010248	RES	WW	99.75 K	1/4%	W	IRC	C6618T9
R26	040062	RES	VARI	500 OHM	10%	1.5 W	CTS	110
R27	010248	RES	WW	99.75 K	1/4%	W	IRC	C6618T9
R28	040053	RES	VARI	5 K	10%	1.5 W	CTS	110
R29	010248	RES	WW	99.75 K	1/4%	W	IRC	C6618T9

PCB ASSEMBLY SWITCH PANEL-DC AUTO RANGE 010 400784

P A R T S L I S T

REF DES	DANA P/N	PART	TYPE	DESCRIPTION	MANUFAC	MANUFAC P/N
C3	110044	CAP	ELECT	50 MFD 50 V 20%	DUCATI	50-50
C4	121090	CAP	MYLAR	.015 MFD 100 V 10%	CDE	WMF1S15
C5	121091	CAP	MYLAR	.033 MFD 100 V 10%	CDE	WMF1533
C6	101182	CAP	CERAM	47 PFD 500 V 10%	AEROVOX	TCD-N750
C8	121090	CAP	MYLAR	.015 MFD 100 V 10%	CDE	WMF1S15
A-CR1	210083					
B-CR1	211083	DIODE	SILICO	018	DANA	211083
A-CR2	211083	DIODE	SILICO	018	DANA	211083
ACR26	211083	DIODE	SILICO	018	DANA	211083
ACR27	211083	DIODE	SILICO	018	DANA	211083
BCR26	211083	DIODE	SILICO	018	DANA	211083
CCR27	211083	DIODE	SILICO	018	DANA	211083
CCR26	211083	DIODE	SILICO	018	DANA	211083
CR37	210004	DIODE	SILICO	SD-4		
CR38	210004	DIODE	SILICO	SD-4		
CR39	211083	DIODE	SILICO	018	DANA	211083
CR40	211083	DIODE	SILICO	018	DANA	211083
CR41	211083	DIODE	SILICO	018	DANA	211083
CR42	211083	DIODE	SILICO	018	DANA	211083
K1	310013	RELAY	REED	SPST 24V	WHEELOCK	2961A X6
Q1 THRU Q4	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
Q5 THRU Q8	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
A-R8	000473	RES	CARBON	47 K 5% 1/4 W	OHMITE	RC07GF473J
B-R8	000473	RES	CARBON	47 K 5% 1/4 W	OHMITE	RC07GF473J
R15	000820	RES	CARBON	82 OHM 5% 1/4 W	OHMITE	RC07GF820J
R16	000205	RES	CARBON	2 M 5% 1/4 W	OHMITE	RC07GF205J
R17	000105	RES	CARBON	1 M 5% 1/4 W	OHMITE	RC07GF105J
R18	000514	RES	CARBON	510 K 5% 1/4 W	OHMITE	RC07GF524J
R20	000155	RES	CARBON	1.5 M 5% 1/4 W	OHMITE	RC07GF155J
R21	000912	RES	CARBON	9.1 K 5% 1/4 W	OHMITE	RC07GF912J
R22	000754	RES	CARBON	750 K 5% 1/4 W	OHMITE	RC07GF754J
S1	600236					
S2	600218					

PCB APCB ASSEMBLY AUTO RANGE - 402198

P A R T S L I S T

REF DES	DANA P/N	PART	TYPE	DESCRIPTION	MANUFAC	MANUFAC P/N
C1	101174	CAP	CERAM	.001 MFD 500 V 10%	AEROVOX	SCD3X5F
E-C1	121092	CAP	MYLAR	.0022 MFD 100 V 10%	CDE	WMF1D22
C3	121092	CAP	MYLAR	.0022 MFD 100 V 10%	CDE	WMF1D22
CR1	211083	DIODE	SILICO	018	DANA	211083
CR2	211083	DIODE	SILICO	018	DANA	211083
CR3	211083	DIODE	SILICO	018	DANA	211083
ACR1	210004	DIODE	SILICO	SD-4		
ACR2	210004	DIODE	SILICO	SD-4		
ACR3	210004	DIODE	SILICO	SD-4		
CR25	211083	DIODE	SILICO	018	DANA	211083
CR37	211083	DIODE	SILICO	018	DANA	211083
Q3	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
Q4	200035	TRANS	SILICO NPN	014	DANA	200035
Q7	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
Q8	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
Q9	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
Q10	200043	TRANS	SILICO NPN	2N3565	FAIRCHILD	2N3565
R5	CC0822	RES	CARBON	8.2 K 5% 1/4 W	OHMITE	RC07GF822J
R6	CC0153	RES	CARBON	15 K 5% 1/4 W	OHMITE	RC07GF153J
R7	CC0204	RES	CARBON	200 K 5% 1/4 W	OHMITE	RC07GF204J
R8	CC0243	RES	CARBON	24 K 5% 1/4 W	OHMITE	RC07GF243J
R10	CC0243	RES	CARBON	24 K 5% 1/4 W	OHMITE	RC07GF243J
R16	CC0222	RES	CARBON	2.2 K 5% 1/4 W	OHMITE	RC07GF222J
R17	CC0153	RES	CARBON	15 K 5% 1/4 W	OHMITE	RC07GF153J
R18	CC0512	RES	CARBON	5.1 K 5% 1/4 W	OHMITE	RC07GF512J
R19	CC0222	RES	CARBON	2.2 K 5% 1/4 W	OHMITE	RC07GF222J
R20	CC0153	RES	CARBON	15 K 5% 1/4 W	OHMITE	RC07GF153J
R21	CC0512	RES	CARBON	5.1 K 5% 1/4 W	OHMITE	RC07GF512J
R22	CC0243	RES	CARBON	24 K 5% 1/4 W	OHMITE	RC07GF243J
R23	CC0822	RES	CARBON	8.2 K 5% 1/4 W	OHMITE	RC07GF822J
R24	CC0104	RES	CARBON	100 K 5% 1/4 W	OHMITE	RC07GF104J
R26	CC0822	RES	CARBON	8.2 K 5% 1/4 W	OHMITE	RC07GF822J
R27	CC0153	RES	CARBON	15 K 5% 1/4 W	OHMITE	RC07GF153J
R28	CC0512	RES	CARBON	5.1 K 5% 1/4 W	OHMITE	RC07GF512J
E-R8	CC0512	RES	CARBON	5.1 K 5% 1/4 W	OHMITE	RC07GF512J
F-R8	CC0512	RES	CARBON	5.1 K 5% 1/4 W	OHMITE	RC07GF512J

Warranty

It is the practice of Dana Laboratories, Incorporated, to manufacture only products of a quality that will merit customer satisfaction. The company recognizes that customer satisfaction is achieved, not only by delivering products meeting advertised performance specifications and having a high level of reliability, but also by honestly and efficiently fulfilling their warranty obligations as set forth below.

Dana Laboratories, Inc., agrees to correct, either by repair or replacement, any defect of material or workmanship in Dana-manufactured units or components which develop within one year after delivery of the equipment to the original purchaser — provided that the equipment has been subjected only to normal and proper use.

In the event of failure of any component delivered with Dana equipment, but not manufactured by Dana Laboratories, assistance will be given the customer in obtaining, from the original manufacturer, reasonable adjustment under that manufacturer's warranty.

Any item claimed to be defective during the warranty period must be returned to Dana Laboratories, Inc., with transportation charges prepaid. The item will be repaired and returned to the purchaser with return transportation prepaid by Dana unless, of course, the item is found not to be defective or found to be damaged by misuse — in which case it will be returned to the purchaser with repair and transportation billed collect.

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